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An Experimental Study on Rubberized Concrete by Using Waste Material with the Addition of Human Hair as Fiber

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Abstract— Rubberized concrete is a concrete in which the scrap tire rubber is used as a partial replacement of coarse aggregate. It has been estimated that nearly 1000 million tires reach the end of their useful lives every year which imposes a serious problem to dispose of this huge bulk of waste rubber creating a threat to environment. To protect the environment from this problem researchers are consistently exploring to use this rubber as a source to replace the natural resources such as stone aggregates which will also address the growing demand of natural construction material. In the present experimental study, rubberized concrete is to be studied by Compressive strength, Flexural strength, Split tensile strength for M30 Rubberized concrete by replacing 15%,25% & 35% of coarse aggregate by rubber, fine aggregate by foundry sand and comparing it with plain M30 concrete.
Keywords— Rubberized Concrete, Compressive Strength, Split Tensile Strength, Flexural Strength

I. INTRODUCTION

Traditional concrete is primarily made up of four fundamental ingredients, i.e. coarse aggregate, fine aggregate (i.e. sand), cement and water. It has been used for over a century. Concrete occupies a unique place among modern construction materials. It gives freedom to mould the structure to any shape which is not possible with other material. Rubberized Concrete is the concrete in which coarse as well as fine aggregate is replaced by scrap tyre rubber. Nowadays, large quantities of scrap tires are generated each year globally. If these waste tires are not disposed of properly, the resulting stockpiles would cause major health risks for the public and environment. This is dangerous not only due to potential environmental threat, but also from fire hazards and provide breeding grounds for rats, mice, vermin's and mosquitoes. To protect environment from this damage, waste tyre rubber should be reused. In the last 20 years, a lot of work by using these waste materials has been done in various civil engineering projects. By using waste tyre rubber as a coarse aggregate as well as fine aggregate in concrete the natural resources can be saved and environmental pollution can be minimize. Partially replacing the coarse or fine aggregate of concrete with some quantity of small waste tire cubes can improve qualities such as low unit weight, high resistance to abrasion, absorbing the shocks and vibrations, high ductility and brittleness and so on to the concrete. It has been observed that the use of waste tyre as aggregate replacement improves the toughness and sound insulation properties of concrete. Rubberized concrete is specially recommended for concrete structures located in areas of severe earthquakes risk and also for applications submitted to severe dynamic actions like railway sleepers. The rubberized concrete is affordable, cost effective and withstand for more pressure, impact and temperature when compare it with conventional concrete. It is observed that the Rubber Modified Concrete (RMC) is very weak in compressive and tensile strength. But they have good water resistance with low absorption, improved acid resistance, low shrinkage, high impact resistance, and excellent sound and thermal insulation. Rubberized Concrete improves the mechanical and dynamic properties such as energy absorption, ductility and resistance. However, this may decrease compressive strength of the concrete which may be compensated by adding micro silica to the rubber containing concrete. It has been considered that rubberized concrete would be very suitable to be used in architectural applications such as nailing concrete, where high strength is not necessary, in wall panels that require low unit weight, jersey barriers in which high strength is not necessary. In recent years, much attention has been attracted towards using silica fumes in concrete to increase the strength of the concrete. By adding silica fume and super plasticizers in the concrete compressive strength can be increased.

II. LITERATURE REVIEW

Modifications of construction materials have an important bearing on the building sector. Several attempts have been therefore made in the building material industry to use waste material. This contributes the reduction of waste material dumping problems successfully by utilizing them. Many researchers has been studied the effect of various waste material on the performance of concrete.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Biel and Lee (1996) reported that the failure of plain concrete cylinder's resulted in explosive conical separations of cylinders, leaving the specimens in several pieces. As the amount of rubber in concrete was increased, the severity and explosiveness of the failures decreased. Failure of concrete specimens with 30, 45 and 60% replacement of fine aggregate with crumb rubber particles occurred as a gradual shear that resulted in a diagonal failure plane.

Eldin and Senouci (1993) on the basis of test results showed that when the coarse aggregate was fully replaced by coarse rubber chips there was about 85% reduction in compressive strength and 50% reduction in tensile strength. However, when the fine aggregate was fully replaced by fine crumb rubber specimens lost up to 65% of their compressive strength and up to 50% of their tensile strength. He also showed that when loaded in compression specimens containing rubber did not exhibit brittle failure.

Guneyisi et al. mentioned that the strength of concretes containing crumb rubber, silica fume and tyre chips decreases with rubber content. These authors suggest that it is possible to produce a 40MPa concrete replacing a volume of 15% of aggregates by rubber waste.

Ghaly & Cahill studied the use of various percentage of rubber in concrete (5%, 10%, and 15%) by volume noticed that as rubber content increases compressive strength decreases.

Ganjian et al. also confirmed the decrease in compressive strength for increasing rubber content.

However, a slight increase in compressive strength is observed when 5% of chipped rubber replaced the coarse aggregates probably due to a better grading of the mixture.

Joe et al. demonstrated that addition of nanomaterials can contribute to the improvement of compressive strength of concretes. They compared the effect of conventional pozzolanic additives such as silica fume and nanoadditives. While most conventional additives begin to enter the hydration reaction after a passive period, nanoadditives enter the hydration reaction once they are added to the cement paste.

Snelson et al.used shredded tyre chips (15 to 20mm) in concrete for aggregate replacement in different percentages (2.5%, 5% and 10%) reporting a loss in compressive strength. The results show that the rubber mixtures also containing pulverized fuel ash as partial cement replacement presented major compressive strength loss. This means that the low adhesion between the cement paste and the rubber waste becomes even lower if admixtures with low pozzolanic activity are used.

Topcu (1995) analyzed the results of compression tests conducted on ordinary concrete and rubberized concrete and observed that the compressive strength of ordinary concrete obtained from cube tests is higher than that obtained from cylinder tests.

Valadares studied the performance of concretes with the equal volume replacement of rubber wastes confirming the decrease of compressive strength.

From the above past literature study, it has been concluded that compressive strength as well as flexural strength of the concrete decreases with the increase in the tyre rubber content. As the amount of rubber in concrete increases, the severity and explosiveness of the failures decreased. It has also been concluded that compressive strength can be improved by adding micro silica in the Rubberized Concrete.

III. MATERIAL INVESTIGATION

A. Cement

Ordinary Portland cement (OPC) 43 Grade from single batch was used for all concrete mixes. It was fresh and without any lumps. Specific Gravity of Cement is 3.15.

B. Fine Aggregate

In this experimental study, locally available sand has been used and conformed to Indian Standard Specifications IS: 383-1970. Sand used was river sand with specific gravity 2.5 the fine aggregate was in zone II. The water absorption of fine aggregate is 3.425%.

C. Coarse Aggregate

The coarse aggregate was crushed angular with a maximum size of 20mm. The specific gravity of coarse aggregate is 2.53. Water absorption of coarse aggregate is 0.6%.

D. Silica Fume

Silica fume used in this experimental study was procured from DBS Building Products Pvt. Ltd., Delhi.

E. Foundry Sand

Foundry Sand used was taken from the foundries. The specific gravity of foundry sand f is 2.36. Water absorption of coarse

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aggregate is 2%.

F. Tyre Rubber Chips

Tyre Rubber chips were procured from Motor Market, Ambala City. It is used to partially replace the coarse aggregate and having the dimension of about 20 mm. The particle shape of the rubber aggregate was irregular and rough.

IV. CASTING OF SPECIMENS

Standard cubical mould of size 150mm x 150mm x 150mm was used to prepared concrete specimens to test compressive strength of concrete. Cylindrical mould of size 300mm x 150mm was used to prepared concrete specimens to test split tensile strength of concrete. To test flexure strength beams of size 500mm x 100mm x 100mm were used to prepare concrete specimens.

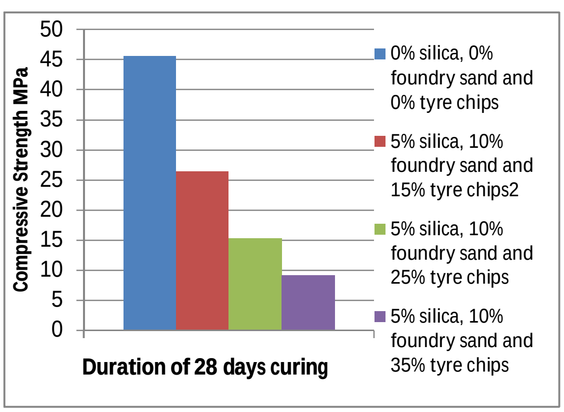
V. RESULTS AND DISSCUSSION

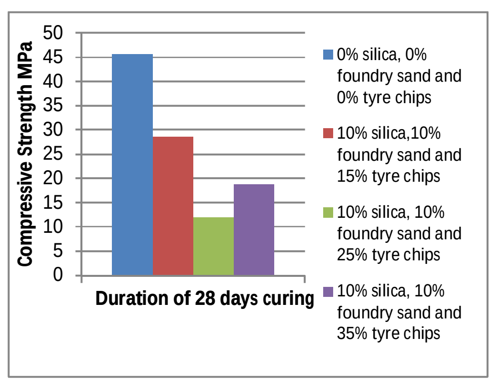
A. Compressive Strength

The concrete structure is mainly designed for its compressive strength as it is weak in tension and strong in compression. Hence to compare the conventional concrete and rubberized concrete made with waste tyre rubber, the compressive strength has been observed by moulding concrete cube specimen.

Table 1
CUBE COMPRESSIVE STRENGTH

S.No.	Mix Proportion						Average Load Failure (KN)	Average Compressive Strength (MPa)
	Cement (kg)	Percentage of Silica Fume (kg)	Sand (kg)		Aggregate (kg)			
			Sand	Foundry Sand	Stone Aggregate	Rubber Aggregate		
1	3.54	-	7.18	-	11.85	-	1027	45.64
2	3.37	5% (0.18)	6.46	10% (0.72)	11.85	15%(1.07)	594	26.40
3	3.37	5% (0.18)	6.46	10% (0.72)	11.85	25%(1.78)	344	15.29
4	3.37	5% (0.18)	6.46	10% (0.72)	11.85	35%(2.49)	204	9.07
5	3.19	10% (0.35)	6.46	10% (0.72)	10.79	15%(1.07)	644	28.62
6	3.19	10% (0.35)	6.46	10% (0.72)	10.08	25%(1.78)	270	12.00
7	3.19	10% (0.35)	6.46	10% (0.72)	9.36	35%(2.49)	424	18.84
8	3.01	15% (0.53)	6.46	10% (0.72)	10.79	15%(1.07)	474	21.07
9	3.01	15% (0.53)	6.46	10% (0.72)	10.08	25%(1.78)	164	7.29
10	3.01	15% (0.53)	6.46	10% (0.72)	9.36	35%(2.49)	239	10.62





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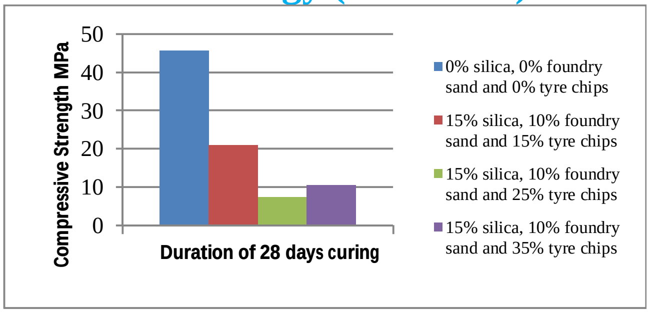

Fig. Effect of Foundry Sand and Tyre Chips on Compressive Strength

B. Split Tensile Strength

The result of split tensile strength after 28 days of curing of conventional and rubberized concrete is shown in Table 2

Table 2

CYLINDER SPLIT TENSILE STRENGTH

S.No.	Mix Proportion						Average Load Failure (KN)	Average Split Tensile Strength (MPa)
	Cement (kg)	Percentage of Silica Fume (kg)	Sand (kg)		Aggregate (kg)			
			Sand	Foundry Sand	Stone Aggregate	Rubber Aggregate		
1	22.27	-	45.11	-	74.46	-	153.31	2.17
2	21.15	5% (1.11)	40.60	10% (4.51)	67.76	15%(6.70)	207.00	2..93
3	21.15	5% (1.11)	40.60	10% (4.51)	63.29	25%(11.17)	182.28	2.58
4	21.15	5% (1.11)	40.60	10% (4.51)	58.82	35%(15.64)	156.14	2.21
5	20.04	10% (2.23)	40.60	10% (4.51)	67.76	15%(6.70)	184.40	2.61
6	20.04	10% (2.23)	40.60	10% (4.51)	63.29	25%(11.17)	213.37	3.02
7	20.04	10% (2.23)	40.60	10% (4.51)	58.82	35%(15.64)	176.63	2.50
8	18.93	15% (3.34)	40.60	10% (4.51)	67.76	15%(6.70)	150.49	2.13
9	18.93	15% (3.34)	40.60	10% (4.51)	63.29	25%(11.17)	140.60	1.99
10	18.93	15% (3.34)	40.60	10% (4.51)	58.82	35%(15.64)	124.35	1.76

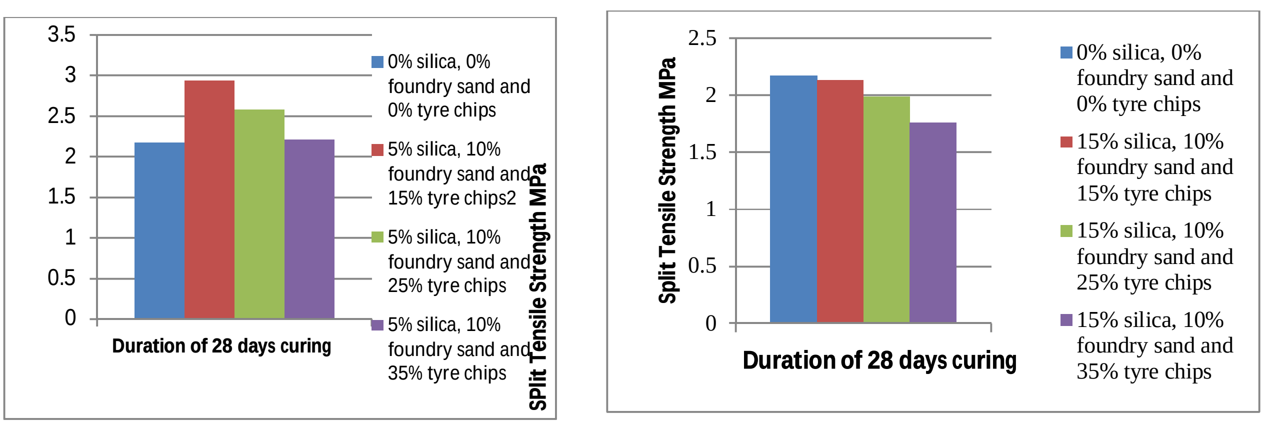

Fig. Effect of Foundry Sand and Tyre Chips on Split Tensile Strength

C. Flexural Strength

The result of flexural strength after 28 days of curing of conventional and rubberized concrete is shown in Table 3

Volume 3 Issue IX, September 2015
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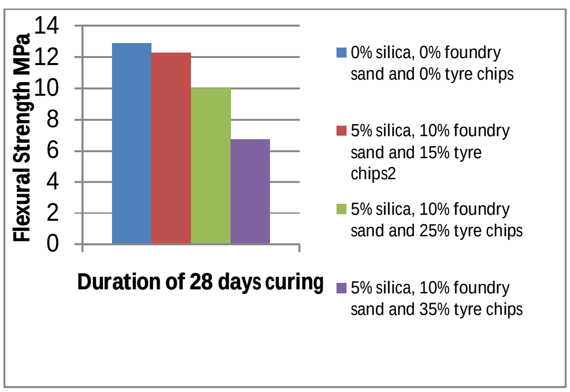
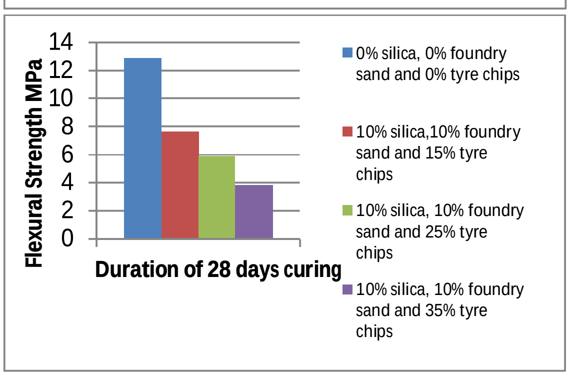
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Table 3

BEAM FLEXURAL STRENGTH

S.No.	Mix Proportion						Average Load Failure (KN)	Average Flexural Strength (MPa)
	Cement (kg)	Percentage of Silica Fume (kg)	Sand (kg)		Aggregate (kg)			
			Sand	Foundry Sand	Stone Aggregate	Rubber Aggregate		
1	5.25	-	10.64	-	17.57	-	25.75	12.87
2	4.99	5% (0.26)	9.58	10% (1.06)	15.99	15%(1.58)	24.5	12.25
3	4.99	5% (0.26)	9.58	10% (1.06)	14.94	25%(2.64)	20	10
4	4.99	5% (0.26)	9.58	10% (1.06)	13.88	35%(3.69)	13.5	6.75
5	4.73	10% (0.53)	9.58	10% (1.06)	15.99	15%(1.58)	15.25	7.625
6	4.73	10% (0.53)	9.58	10% (1.06)	14.94	25%(2.64)	11.75	5.875
7	4.73	10% (0.53)	9.58	10% (1.06)	13.88	35%(3.69)	7.75	3.875
8	4.46	15% (0.79)	9.58	10% (1.06)	15.99	15%(1.58)	11.5	5.75
9	4.46	15% (0.79)	9.58	10% (1.06)	14.94	25%(2.64)	13	6.5
10	4.46	15% (0.79)	9.58	10% (1.06)	13.88	35%(3.69)	17.25	8.625





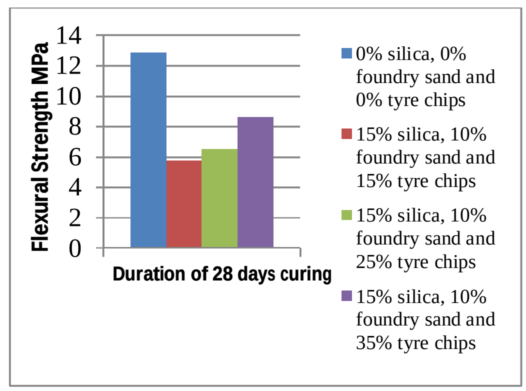


Fig. Effect of Foundry Sand and Tyre Chips on Flexural Strength

VI. CONCLUSION

The Compressive Strength of the Rubberized Concrete made by replacing cement by silica fume, sand by foundry sand and aggregate by varying percentage of waste tyre rubber is lower than the Conventional Concrete which is approximately 42% lower.

The Split Tensile Strength of the Rubberized Concrete made by replacing cement by silica fume, sand by foundry sand and aggregate by varying percentage of waste tyre rubber is higher than the Conventional Concrete which is approximately 35% higher.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

The Flexural Strength of the Rubberized Concrete made by replacing cement by silica fume, sand by foundry sand and aggregate by varying percentage of waste tyre rubber is lower than the Conventional Concrete which is approximately 4.8% lower.

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